(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 261 142 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
27.11.2002 Bulletin 2002/48

(51) Int Cl.[7]: **H04B 1/40**

(21) Application number: **01112404.7**

(22) Date of filing: **21.05.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **Sony International (Europe) GmbH**
10785 Berlin (DE)

(72) Inventors:
- **Eichel, Dirk**
  70327 Stuttgart (DE)
- **Landing, Mikael**
  70327 Stuttgart (DE)
- **Rebmann, Jochen**
  70327 Stuttgart (DE)

(74) Representative: **Rupp, Christian, Dipl.Phys. et al**
Mitscherlich & Partner
Patent- und Rechtsanwälte
Sonnenstrasse 33
80331 München (DE)

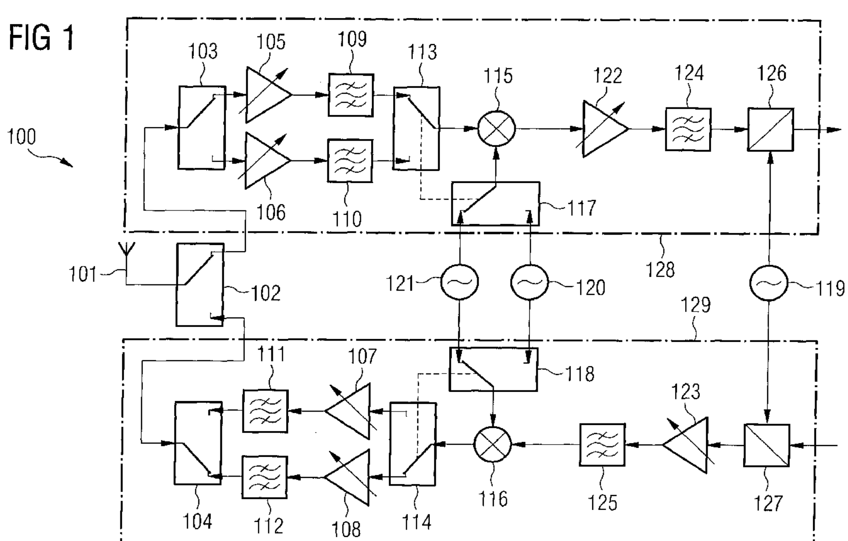
(54) Dual mode transceiver architecture for digital wireless communication

(57) Compared with transceivers that can only be operated at one frequency band, conventional dual mode transceivers covering one 2.450 GHz ISM and one 5.150 GHz to 5.875 GHz band have the problem of an increased power consumption due to their two independent receive chains (RX_1, RX_2) and transmit chains (TX_1, TX_2).

In a first preferred embodiment of the underlying invention a complete transceiver architecture 100 for 2.450 GHz ISM and 5.150 GHz to 5.875 GHz band operation is disclosed, wherein at least one of the herein applied signal down-/upconversion mixers 115 or 116, respectively, can be selectively connected to at least two of the herein applied frequency synthesizing means 120 or 121 being operated at different tuning ranges.

Thereby, said down-/upconversion mixers 115 and 116 serve as shared components that can be used for either 2.450 GHz ISM or 5.150 GHz to 5.875 GHz band operation, in order to reduce the number of the used components and the power consumption of the dual mode transceiver, and to achieve savings in cost, complexity, board size and energy.

FIG 1



EP 1 261 142 A1

Description

FIELD AND BACKGROUND OF THE INVENTION

[0001] The present invention relates to wireless communication systems and, more particularly, to dual band mobile stations (MS) which must be able to transmit and receive in two separate frequency bands.

[0002] The world of wireless communication has been changing very rapidly over the last few years. Due to ever emerging new applications and dropping prices the demand has been growing explosively. The introduction of digital data communication in combination with digital signal processing has created the foundation for the development of many new wireless applications. High-quality digital wireless networks for voice communication with global and local coverage, like the GSM and the DECT system, are early examples of the wide variety of new wireless applications that will become available in the near future.

[0003] The new evolution in wireless communications set new requirements for the wireless interfaces, the so-called "transceivers" (wherein each transceiver consists of one transmitter and one receiver). A transceiver is the two-way interface. between an information source and the communication channel which will be used to exchange the information. The transmitter translates a data stream into a form which is suited for the communication channel. This "translation" is called modulation.

[0004] The specific nature of wireless communication channels makes that almost all receiver types for wireless applications consist of two parts: 1. a front-end part which performs the frequency downconversion, and 2. a back-end part in which the actual demodulation of the signal is performed. A third part, called the user-end, transforms the received information into a form suitable for the user. This part is however not considered to be part of the receiver. The basic way of the receiver operation is always the same: The downconverter mixes the antenna signal down from its high operating frequency to a suitable, lower frequency on which then the demodulation can be performed in an elegant way. The received antenna signal consists of a very broad spectrum of many different information channels and noise sources. The wanted signal is, in its modulated form, only a very small part of this broad spectrum. The front-end part converts this antenna signal in a signal that can be demodulated by the back-end part in a feasible way.

[0005] The receiver front-end has to be able to downconvert very small signals (e.g. a bandwidth of a few 100 kHz and an amplitude which can be as low as 5 μV_{rms}) from a high operating frequency (typically between 900 MHz and 2.4 GHz) to a much lower intermediate frequency (typically 10 MHz or lower) or to the baseband, where it can be demodulated. This small signal is present in a noisy environment and it can be sourrounded with other signals which can be as large as 300 mV_{rms}. This requires from the front-end a high operating frequency and, at the same time, a high input dynamic range. These specifications make that the front-end is always realized as an analog circuit which mainly consists of mixers, filters and variable gain amplifiers (VGAs) which, in successive stages, filter the antenna signal further and further, and downconvert it to lower frequencies to become finally a low frequency signal that consists only of the modulated wanted signal.

[0006] The demodulation technique that is used in the back-end part of the receiver mainly depends on two aspects: 1. the modulation technique that is applied, and 2. the type of front-end that is used. It is obvious that the type of demodulator depends on the modulation that has been performed: for an FM modulated signal an FM demodulator is required and for a QPSK modulated signal a QPSK demodulator is required.

[0007] A front-end has no influence on the form of the wanted signal, but it does determine the center frequency at which the wanted signal is provided to the back-end part. There are two possibilities: The wanted signal is either provided on an intermediate frequency (IF) or it is provided as a quadrature baseband signal.

[0008] Today, most new wireless applications use digital data communication which has many advantages such as high quality communication due to signal regeneration and error correction systems, computer control and the communication and integration of different services in one application. In a receiver for a digital wireless application the demodulation is always performed by a digital signal processor (DSP). Almost all these DSPs perform the demodulation on a quadrature baseband signal. The front-end for a digital wireless receiver must therefore produce these baseband quadrature I and Q signals. This, however, not necessarily has to be done in an analog way. The wanted signal must be downconverted to an intermediate frequency (IF, e.g. 10.7 MHz). After sampling, it can then be further downconverted to the baseband by the DSP. Thus, in this case, the final part of the front-end is digital.

[0009] The most often used receiver topology is, without any doubt, the heterodyne receiver. Its main feature is the use of an intermediate frequency (IF). For this reason the heterodyne receiver is often also called the IF receiver. Thereby, the received signal is downconverted from its carrier frequency (RF) to an intermediate frequency (IF) by multiplying it with a single sinusoidal signal. The signal can then be demodulated on this frequency or it can be further downconverted. Only in a single stage version the signal is not further downconverted.

[0010] The main disadvantage of an heterodyne receiver is that, apart from the wanted signal (WS), also an unwanted signal (US), called the mirror signal, is converted to the intermediate frequency (IF). Filtering a narrow channel that is centered at high frequencies and accompanied by large interferers demands filters with prohibitively high quality (Q)

values. To bring the center frequency f_{RF} of a received modulated signal

$$S_{RF}(t) = S_{RF}\cdot\cos(2\pi\cdot f_{RF}t+\Phi),$$

wherein
f_{RF}: center frequency of the received signal $S_{RF}(t)$,
S_{RF}: amplitude of the received signal $s_{RF}(t)$,
Φ: phase of the received signal $s_{RF}(t)$,
from f_{RF} to f_{IF} ($f_{IF} < f_{RF}$) the signal is first mixed with a sinusoidal local oscillator (LO) signal

$$S_{LO}(t) = S_{LO}\cdot\cos(2\pi\cdot f_{LO}t+\Psi) \text{ with } f_{LO} := f_{RF} - f_{IF},$$

wherein
f_{LO}: frequency of the local oscillator signal $s_{LO}(t)$,
S_{LO}: amplitude of the local oscillator signal $s_{LO}(t)$,
Ψ: phase of the local oscillator signal $s_{LO}(t)$,
f_{IF}: intermediate frequency (IF),
thereby yielding a band B_1 around the intermediate frequency f_2 and another band B_2 around the frequency $2\cdot f_{RF} - f_{IF}$. A lowpass filter then removes the latter. This operation is called "downconversion mixing". Because of its typically high noise, a downconversion mixer normally is preceded by a low-noise amplifier (LNA).

[0011] In a heterodyne architecture, these bands B_1 and B_2 are symmetrically located above and below the frequency f_{LO} of the local oscillator (LO), respectively, and downconverted to the same intermediate frequency (IF). If the received band of interest (WS) is centered around

$$f_{RF} = f_{LO} - f_{IF} =: f_{WS} \ (1),$$

wherein
f_{WS}: center frequency of the wanted signal (WS),
then the corresponding image (US) is centered around

$$2 \cdot f_{LO} - f_{RF} = f_{LO} + f_{IF} =: f_{US} \ (2),$$

wherein
f_{US}: center frequency of the unwanted signal (US).
From (1) and (2) follows that $f_{IF} = ½\cdot |f_{US}-f_{WS}|$ (*).

[0012] The downconversion of the wanted signal (WS) and the unwanted signal (US) to the intermediate frequency (IF) can be seen in the following trigonometric equation which shows the modulation of the received antenna signal s_{RF} (t) with the sinusoidal local oscillator signal $s_{LO}(t)$:

$$\begin{aligned} & s_{RF}(t) \cdot s_{LO}(t) \\ &= S_{RF} \cdot [\cos(2\pi\cdot f_{WS}t+\Phi)+\cos(2\pi\cdot f_{US}t+\Phi)]\cdot S_{LO}\cdot\cos(2\pi\cdot f_{LO}t+\Psi) \\ &= ½\cdot S_{RF}\cdot S_{LO}\cdot [\cos(2\pi\cdot (f_{LO}-f_{WS})t-\Phi+\Psi)+\cos(2\pi\cdot (f_{LO}+f_{WS})\, t+\Phi+\Psi) \\ &\quad + \cos(2\pi\cdot (f_{LO}-f_{US})\, t-\Phi+\Psi)+\cos(2\pi\cdot(f_{LO}+f_{US})\, t+\Phi+\Psi)]. \end{aligned}$$

[0013] Hence, the unwanted signal (US) has to be suppressed before it is mixed down to the intermediate frequency (IF). This is done by means of a high frequency (HF) filter. Such an HF filter can only be realized when the intermediate frequency (IF) is high enough because the wanted signal (WS) must be relatively far away from the unwanted signal (US), as can be seen from equation (*). Even when the ratio f_{WS}/f_{IF} is as small as 10, the specifications for the HF filter are very severe. The HF filter must have a very high quality factor Q of 50 to 100, it must have a sufficiently high order (up to 6th order for high quality applications) and in some cases the center frequency must be tunable. A filter with

these specifications can not be integrated. The accuracy requirements would, for a Q of 20 or more, be much too high for an integrated HF filter because their power consumption is proportional to Q^2, resulting in totally unacceptable power consumption specifications. HF filters are therefore always realized as discrete off-chip components, but these are very expensive and vulnerable in use. Off-chip components require extra handling, extra board space and an increased pin count, and they reduce the board yield. Their power consumption is high because they have to be driven at a low impedance (e.g. 50 Ω) to compensate for the large parasitic capacitances which are inherently present due to their large physical size.

[0014] Once the signal is downconverted to the intermediate frequency (IF), it has to be further filtered in order to obtain the wanted signal. This filter must also have a sufficiently high quality value Q (e.g. 50) and order (8th or 10th order). Integrating these IF filters is also very hard. Again, these are high quality discrete components and their use is very expensive compared to integrated components.

[0015] Integrated heterodyne receivers are well-known in many fields of the communications technology. They are characterized by a good image rejection and a good channel selectivity. Unfortunately these kind of receivers comprise several disadvantages: high realization costs, the necessity of a plurality of external components and a high power consumption. Image rejection mixers (IRM) represent an alternative to the above-mentioned receivers. However, IRM architectures are very sensitive to parameter variations, which leads to a worse suppression of the image frequency.

[0016] A low-cost solution with a very high degree of integration, a lower power consumption and the use of a lower power supply voltage are the goals set for new developments in wireless transceiver design. Many efforts have been devoted to the integration of such circuits in low-cost technology in order to reach the goal. Costs have been driven down by technology improvement and better design. What was previously available only in military applications is now available for the mass market. The rapidly growing market and ever emerging new applications create a high demand for a low cost, low power, high portability transceiver solution. The integrability and the power consumption reduction of the digital part will further improve with the continued downscaling of technologies.

[0017] However, the bottleneck for further advancement is the analog front-end. The analog front-end forms the interface between the antenna and the digital signal processor. For the analog front-end, integrability and power consumption reduction are closely related to the physical limitations of the transceiver topology and to the used technology.

[0018] Whereas a few years ago data was still being transmitted by means of extensive fixed network cables, it can be sent today from the sender to the receiver by means of radio waves in a simple, secure and low-cost way due to modern transmission and reception means. Radio-controlled networks today show a plurality of applications, for example in the industrial production, logistics and medicine technolgy. Even in the private environment the use of these networks has already become routine: cordless and cellular phones, pagers, radio controlled garage door openers, alarm systems, remote-controlled devices and machines, Global Positioning Systems (GPS), wireless Local Area Networks (WLAN), they all base on radio-controlled communications systems. Interoperability among the manufacturers and transmission rates similar to the classical Ethernet led to an enormous push of this technology. In the near future systems are supposed to come on the market that are able to perform even cordless voice communication beside conventional data communication by virtue of this WLAN infrastructure, that means convergence of voice and data even in the radio-controlled area. Several concerns have already announced new Access Points (APs) that shall be able to perform wireless voice transmission with Voice-over-IP (VoIP) handsets.

[0019] Radio-controlled mobile networks can adequately be used for stationary or slowly moving terminals (e.g. a user with a lap-top in the hand). Systems like DECT (Digital Enhanced Cordless Telecommunications), Bluetooth and all radio-controlled local area networks, including HIPERLAN, belong to this class. Compared with this, mobile networks as GSM, TETRAx and UMTS (Universal Mobile Telecommunications System) enable fast movement, but they are limited to relatively small multiplex rates of the radio interface up to now. The radio interface is simultaneously available to several terminals for communication. Therefore, the terminals must share the multiplex rate of the respective system. Numerous standards exist today which are optimized for different implementations. For voice, there are applications including DECT, AMPS, GSM, DCS, PCS, CDMA, and so on; for data, there are applications including IEEE 802.11 WLAN, HIPERLAN/2, Bluetooth, Home RF, and so on.

Wireless local area networks

[0020] In Wireless local area networks (WLANs) mobile stations - mostly Notebooks - can communicate over Access Points (AP) fitted at walls or ceilings of buildings by means of infrared or radio technology. Generally, these radio interfaces are connected to a wire-bound LAN. In some cases also peer-to-peer topologies are realizable. Whereas infrared solutions can economically get over short distances with visual contact, distances of about several kilometers can be managed by radio solutions. After proprietary systems have courted the favor of the customers for a long time, the US-American Institute of Electrical and Electronics Engineers (IEEE) passed the standard 802.11 for Wireless-LANs in 1997. This standard has its main roots in the Ethernet protocol for fixed networks and uses the 2.4-GHz band. For the data transfer two procedures are planned:

1. Frequency Hopping Spread Spectrum (FHSS) and
2. Direct Sequence Spread Spectrum (DSSS).

[0021] The date transfer rate is set down to 2 MBit/s. By means of cellular technique a good area covering can be achieved. Even roaming is supported - as with the cellular mobile radio the user does not notice that he is just moving into the area of another cell with his lap-top during a connection.

[0022] The bit rate of 2 MBit/s being technically behind at the standardization date and the lacking interoperability of the devices of different companies caused many manufacturers of mobile networks to additionally implement individual, more efficient transfer modes. In November 1999 a successor came with the IEEE 802.11b-Standard (also known as 802.11 High Rate) who raises the maximum transfer rate to 11 MBit/s.

[0023] In principle, with WLANs complete and also very large networks can be built which do not need any cables. How large these networks can be depends on how many Access Points (APs) can maximally be integrated into a network, and how many stations can be operated by an Access Point. Here there are considerably large differences. 100 or 1,000 MBit/s however - in the backbone not exceptional any more today -, can by far not be achieved even with the fastest WLAN technology.

The HIPERLAN standard

[0024] In the field of radio-controlled networks the performance requirements increase rapidly today. The 2.4-GHz band is exhausted now and the mobile technology must find a way to pass over to the 5-GHz band. The same applies for the already specified 802.11a standard (used transmission rates: principally 6 to 54 MBit/s - however, only 6, 12 and 24 MBit/s were already set down as transmission rates) as for the family of the HIPERLAN standards (High Performance Local Area Network). HIPERLAN was already being developed from 1991 to 1996 by the European Telecommunications Standards Institute (ETSI) - parallel to the IEEE 802.11 standard.

[0025] Although HIPERLAN type 1 exists already as a standard for several years, and although it offers Quality-of-Service (QoS) parameters and the handling of isochronal data traffic besides a high transmission rate of up to 24 MBit/s, this variant has not been able to catch on up to now. The big breakthrough did not occur. HIPERLAN/1 uses the Gaussian Minimum-Shift-Keying modulation (GMSK) and coexists with the existing WLANs in the 2.4-GHz band.

[0026] In order to be able to satisfy future demands on radio-controlled LANs, a new class of WLAN standards is necessary which supports Quality of Service (QoS), handover and data integrity. For the completion of the HIPERLAN/1-standard a new project was started in order to define the radio-controlled version of the Asynchronous Transfer Mode (ATM). This radio-controlled ATM project is known as HIPERLAN type 2 (HIPERLAN/2). HIPERLAN/2 was standardized by the ETSI within the scope of the project "Broadband Radio Access Network" (BRAN). This standard meets by far with a higher interest in the industry than HIPERLAN type 1. Of course, the radio-controlled ATM variant supports the same Quality-of-Service parameters (QoS) as the wire-bound version does.

[0027] In addition HIPERLAN/2 has numerous security services and an handover - when a movement occurs between local areas and wide areas or from private to public environments. HIPERLAN/2 shows a very high transmission rate of up to 54 MBit/s on the physical layer (PHY), and up to 36 MBit/s on the network layer (NET). In order to manage these high transmission rates, HIPERLAN/2 uses a modularisation method called Orthogonal Frequency Digital Multiplexing (OFDM) and the Medium Access Control protocol (MAC) which is based on dynamic TDMA/TDD.

[0028] The most important features of the HIPERLAN/2-technology are:

- a high-speed data transfer,
- a connection-orientated working method,
- a Quality-of-Service (QoS) support as with ATM,
- an automatic frequency definition,
- a support of security features,
- a mobility support,
- independence of network and application, and
- a power-saving working method.

[0029] A HIPERLAN/2-network typically consists of several cascadable access points (APs) which allow a complete or partial radio supply in a geographic area. Mobile terminals (MTs) communicate over the HIPERLAN/2 radio interface with the APs. The MTs can move within this field independently, and are supplied automatically by the best AP; an AP consists in this case of an Access Point Controller (APC) and one or several Access Point transceivers (APTs). The APs select automatically the optimal frequency channel, so that no frequency planning is necessary. When operated in the 5-GHz band, the MTs may move around the AP within a radius of about 50 meters. Connections are realized by TDMA/TDD over the air interface. In this case, two types of combinations are possible: point-to-point and point-to-

multipoint. Point-to-point connections are bidirectional, whereas point-to-multipoint connections can only be unidirectionally (in direction to the respective MT).

ISM bands

[0030] The so-called ISM bands (ISM: Industrial, Science and Medicine) assigned by the World Administrative Radio Conference (WARC), allow to implement a series of services that are not allowed in other frequency bands, or that can be assigned only in long-term frequency allocation procedures. In particular, data services as keyless entry systems, garage door controls, alarm systems, etc., called "short range devices", can already be found today in these frequency bands. But even information systems and communications systems used for house automatization can increasingly be found in these frequency bands.
[0031] The challenge of wireless data transmission is the limited available bandwidth of the radio channel at high data rates. Especially in indoor WLAN systems the multi-chain radio channel is another limiting factor. The requirement of high transmission bandwidths due to the high data rates led to the use of the "Industrial Scientific Medical" (ISM) bands. As WLAN systems are not the only operators in the ISM bands, WLAN systems have to be robust against disturbances of other systems. Two possible WLAN standards for the ISM bands are the IEEE 802.11 standard and the Bluetooth standard.

The IEEE 802.11 standard

[0032] The standard IEEE 802.11 describes the functions and services which are needed for the construction of IEEE 802.11 networks. Therefore, procedures and signaling techniques are defined on the physical layer (PHY), as encrypting procedures in order to guarantee the secrecy of the user data. IEEE 802.11 was developed for the use in said ISM bands. The Federal Communications Commission (FCC) - the regulation authority of the United States of America - has therefore prescribed maximum transmission powers, limits for the outer-band radiation and the use of spread spectrum procedures for the noise reduction of already existing communications systems. For this purpose, the frequency bands of 902 to 928 MHz, 2,400 to 2,483.5 MHz, 5,150 to 5,350 MHz and 5,725 to 5,825 MHz were determined as ISM bands. IEEE 802.11 defines two different transmission methods on the physical layer (PHY) in the 2.4-GHz frequency band:

1. Frequency Hopping Spread Spectrum (FHSS), and
2. Direct Sequence Spread Spectrum (DSSS).

[0033] A further alternative represents the use of an infrared-in-terface. The available data rate for an IEEE 802.11 user is 1 MBit/s or 2 MBit/s, optionally. Besides, a modem with a transmission rate of 20 MBit/s at 5 GHz was specified some years ago that uses the frequency bands released by the FCC for the so-called Unlicensed National Information Infrastructure (U-NII):

Band of operation [GHz]	Maximum transmit power [mW]
5.15 to 5.25	50
5.25 to 5.35	250
5.725 to 5.825	1,000

Bluetooth 1.0

[0034] Since summer 1999 the standard Bluetooth 1.0 exists which works just the same as IEEE 802.11. In contrast to the IEEE 802.11 standard it uses an especially small transceiver (transmitter/receiver) unit however. Bluetooth works at the 2.4-GHz band as IEEE 802.11a and IEEE 802.11b. The signals are converted by Frequency Hopping (FH). Aside from the band-width - the multiplex data rate at the radio interface is about 700 kBit/s - the range is also limited (approximately 10...100 m). Hence, the application of this technology is virtually limited to the private area or to small offices. But up to eight devices can be connected with each other. Thus, notebooks, personal computers, modems, printer, radio controls, Personal Digital Assistants (PDA) and other digital accessories in the narrow environment can communicate with each other.
[0035] It is foreseeable, that the usage of radio-controlled network technologies will increase in the near future, and new fields of application will be opened.
[0036] With the allocation of 300 MHz of bandwidth in the 5 GHz frequency band by the Federal Communication Commission (FCC) for the Unlicensed National Information Infrastructure (U-NII), high data-rate (up to 54 MBit/s)

wireless local area networks (WLAN) become increasingly popular and important for mobile computing devices such as laptop computers. The European counterpart is the HIPERLAN system, which also operates in the 5 GHz band. In order to meet the potentially high demand for such wireless LAN products, low-cost silicon-based radio frequency (RF) transceiver front-ends, each consisting of a transmitter and a receiver with corresponding antennas, are essential. There have been a number of 5 GHz silicon transmit or receive integrated circuits reported in the literature.

[0037] The evolution of economical Application-Specific Integrated Circuit (ASIC) elements in the last years allows a power-saving, highly integrated and economical evolution of radio frequency transmitters. Aside from the suitable selection of the components for the sending and receiving components which considerably influence the range and the board space required by the circuit, in particular the possibility of an integrated solution for the antenna represents an essential mile-stone for low-cost circuits. Today individual transmitter and receiver circuits as well as complete transceiver circuits are already available with and without integrated antenna for a frequency range around 434 MHz. Further developments for a frequency range around 868 MHz as well as in the field of the circuits for 2.45 GHz and 5.8 GHz application are available today as demonstrator systems. Whereas the frequency range around 434 MHz is already used by a large number of systems, the area around 868 MHz is still less used by applications systems. A further frequency band around 915 MHz on the other hand is reserved for the US-American communications systems. The other bands at 2.45 GHz and 5.8 GHz are already been useful today for communications systems as identification systems, control systems, wireless data transceivers as well as for WLAN applications. With new modulation methods, as for example Direct Sequence Spread Spectrum (DSSS), it is possible to build up a secure data communication also with difficult channel conditions.

[0038] Current commercial approaches utilize several high quality discrete components to provide high performance required by the transceivers. High component counts and multiple chips in various technologies increase the cost and form factor. A higher integration level is required to lower the cost and form factor. Many efforts are underway to increase the integration level of the transceiver. The ultimate goal would be a single chip transceiver in a single technology with a minimum number of off-chip components, that is, an antenna to receive or transmit the radio frequency (RF) signal, a power supply, and a crystal reference to provide a clean frequency reference. This single chip would act as an interface between the analog RF world and the digital baseband world. With high integration level, cost and form factor is reduced.

[0039] However, many difficulties remain in the process of integration due to the lack of high quality components on chip. In a conventional double conversion receiver, the received signal spectrum is shifted down to the baseband in two steps. During the first step, a local oscillator (RF LO) signal at the radio frequency (RF) is mixed with the radio frequency signal, shifting the signal to a fixed intermediate frequency. To achieve this, the RF LO needs to be tunable and the minimum frequency step must be smaller or equal to the channel spacing of the standard. Then a fixed local oscillator (IF LO) at the intermediate frequency (IF) is used to shift the mixed down version of the received signal to baseband. The RF LO utilizes a low-phase-noise voltage controlled oscillator (VCO) which is coupled to a reference oscillator by a frequency synthesizer loop of low bandwidth. The low bandwidth is desirable in order to minimize the spurious tones in the output frequency spectrum that result from the frequency comparison process. One consequence of the low synthesizer control bandwidth is that the phase noise of the overall synthesizer is dominated by the phase noise of the VCO. This makes the narrow loop bandwidth approach suitable for the implementation with discrete high quality components that is needed by the low phase noise VCO. The need for the external components is not amenable to the integration of the synthesizer.

[0040] A transceiver front-end has to perform three tasks in both the receive chain (RX) and the transmit chain (TX):

- The center frequency of the modulated wanted signal has to be changed from a low frequency to a very high frequency (in the TX chain) or from a very high frequency to a low frequency (in the RX chain).
- All unwanted signals outside the wanted signal channel have to be suppressed so that they do not interfere with the correct operation of the wireless communication link and the digital modem.
- The signal levels have to be adjusted in order to obtain the highest possible performance.

[0041] The transceiver front-end does not make any changes to the shape or form of the modulated signal. This is done in the back-end at low frequencies by means of the modulation and demodulation process. A receiver or transmitter will therefore almost always be realized as a string of operations where each operation is either one of the following three frequency domain operations:

1. a filter, for the suppression of signals outside the wanted signal channel,
2. an amplifier, to adjust the wanted signal level, and
3. a mixer, to change the center frequency.

[0042] From the previous conclusions it may seem that there are not many transmitter and receiver architectures possible. They must after all be a sequence of one or more times a bandpass filter, followed by a variable gain amplifier (VGA) that readjusts the gain, followed by a multiplication with a sine wave generated by a local oscillator (LO). The design of a transceiver consists then of a proper choice of the bandwidth of the bandpass filters, the gain of the VGA and the frequencies of the LO. The only architecture choice that can be made is in how many of these stages the up- or downconversion is done.

[0043] In document US 5,732,330 a transceiver is disclosed having two different voltage controlled oscillators (VCOs) for the two modes of operation, one VCO for the Personal Communication Services (PCS) carrier frequency, the other VCO for the other operating frequency band. The receiver chains do not share components between the two frequency bands of operation up to a further intermediate frequency (IF) processing stage. The transceiver architecture is limited to the frequency bands in accordance with the GSM or the DCS standard, respectively.

[0044] In document EP 0 878 917 A2 a transceiver is disclosed wherein the transceiver architecture is limited to 75 MHz operation in the upper band and to the DCS standard. Furthermore, said transceiver is limited to 25 MHz operation in the lower band and to the GSM standard.

[0045] Document EP 1 059 734 A2 shows a transceiver architecture using two separate chains for the two frequency bands, wherein only one VCO is used as a frequency synthesizer for both chains.

DEFICIENCIES AND DISADVANTAGES OF THE KNOWN SOLUTIONS OF THE PRESENT STATE OF THE ART

[0046] Common dual mode transceiver architectures are using separated receive (RX) and transmit (TX) chains for the different operation frequency bands. Consequently, the number of the used components and the power consumption is very high as each chain has its own filters, mixers and amplifiers. For example, transceivers covering one 2.4 GHz ISM and one band within a 5 GHz to 6 GHz range have the problem of increased power consumption due to two independent receive (RX) and transmit (TX) chains. Because of the required image rejection of the receiver, these transceivers are limited to narrow band operation in the 5 GHz to 6 GHz range.

[0047] Many conventional transceivers show furthermore the restriction that they can only be operated in combination with standards that provide a limited bandwidth. In document EP 0 878 917 A2 a transceiver is disclosed wherein the transceiver architecture is limited to 75 MHz narrow-band operation in the upper band and to the DCS standard. Furthermore, said transceiver is limited to 25 MHz narrow-band operation in the lower band and to the GSM standard.

[0048] In addition conventional transceivers in accordance with the present state of the art do not imply sufficient possibilities for the suppression of interferences due to adjacent channels.

OBJECT OF THE UNDERLYING INVENTION

[0049] In view of the explanations mentioned above, the object of the invention is the provision of a new dual band receiver/transmitter architecture with a reduced number of components in order to obtain lower cost, smaller board size and complexity, and lower power consumption. This object is achieved by means of the features of the independent patent claims. Advantageous features are defined in the dependent patent claims.

SUMMARY OF THE INVENTION

[0050] The underlying invention refers to a new dual band receiver and transmitter architecture, respectively, as well as to a new dual band transceiver architecture being able to receive and/or transmit modulated radio frequency (RF) signals operating on at least two different frequency ranges.

[0051] The solution proposed by a first preferred embodiment of the underlying invention covers all bands in the range of 5,150 MHz to 5,850 MHz and the ISM band at 2.450 GHz. In this particular design only one intermediate frequency (IF) stage is used. The claimed dual mode transceiver architecture 100 is provided with means for a sufficient image rejection to fulfil the requirements of the HIPERLAN/2 standard. Finally, the claimed dual mode transceiver architecture 100 can easily be expanded to other transceiver architectures known from the art.

[0052] For the particular design of a second preferred embodiment of the underlying invention it is necessary to have more than one intermediate frequency (IF) because of the constraints between image rejection and channel selectivity:

- High frequency (HF) channel select filters do not have enough adjacent channel rejection.
- Low frequency (LF) channel select filters, however, may have the necessary adjacent channel attenuation, but the image frequencies fall into the band of the antenna filter for broad band operation.

[0053] The underlying invention comprises a complete transceiver architecture for two different frequency bands

using a high first intermediate frequency (IF_1) for approximately 1 GHz wide band operation and image rejection. The high first intermediate frequency (IF_1) local oscillator (IF LO) and the lower second intermediate frequency (IF_2) chain are shared between 2.450 GHz and 5.150 GHz to 5.875 GHz operation to reduce the number of the used components and the power consumption of the claimed dual mode transceiver in order to achieve savings in cost, complexity, size and energy. Using a frequency doubler allows wide band operation with a narrow tuning range voltage controlled oscillator (VCO) within the frequency band of 1,990 MHz to 2,250 MHz.

[0054] In accordance with the underlying invention, for the high first intermediate frequency (IF_1) a value of 1,200 MHz is chosen, which is approximately 120% of the covered frequency range in the 5.150 GHz to 5.875 GHz band. The mirror frequency is then in the range of 2,750 MHz to 3,450 MHz. An image suppression of 35 dB is achievable. With two filters in series it is possible to fulfil the HIPERLAN/2 requirements. A lower second intermediate frequency (IF_2) and corresponding intermediate frequency (IF) filtering means are used to remove adjacent channel interferers.

[0055] In this approach the lower second intermediate frequency (IF_2) chain and the frequency generation are shared between two modes of operation which reduces the complexity of the dual mode transceiver and reduces power consumption. Due to the usage of a high first intermediate frequency (IF_1) in the range of approximately 120% of the covered bandwidth (approx. 1 GHz) it is possible to support multiple bands (IEEE 802.11a, HIPERLAN/2 indoor and outdoor, U-NII) in the 5.150 GHz to 5.875 GHz area.

[0056] Compared with the cited documents of the prior art mentioned above, several differences can be found:

- The transceiver disclosed in EP 0 878 917 A2 does not use diversity switching at the antenna. Compared with this, the present invention contains means for a diversity switching at the antenna.

- In contrast to the disclosed transceiver of EP 0 878 917 A2 the claimed transceiver architecture in accordance with the underlying invention does not need any diplexer as antenna filters.

- In document EP 0 878 917 A2 the GSM band intermediate frequency (IF) is used as a first intermediate frequency (IF_1) and the filter in the receive chain is used as a first filter. To achieve better selectivity to suppress the adjacent channels, the claimed transceiver architecture in accordance with the underlying invention uses a different intermediate frequency instead of using the 2.450 GHz band as a first intermediate frequency (IF_1).

[0057] The main advantageous differences between the underlying invention and the state of the art are:

a)wide band operation for the range between 5.150 GHz and 5.875 GHz due to a first intermediate frequency (IF_1) of approximately 120% of the used bandwidth,

b)low power consumption due to component sharing between the two operation modes, and

c)use of a half frequency voltage controlled oscillator 243 (VCO3) and a frequency doubler 244 for wide band operation.

[0058] In said second preferred embodiment of the underlying invention a frequency doubler circuit reduces the tuning range of the voltage controlled oscillator 243 (VCO3) by a factor of two. Furthermore, the phase noise (PN) increases by an amplitude offset of

$$\Delta N_{PN} = 20 \cdot \lg(2) \approx 6 \text{ dB}.$$

[0059] Nevertheless, VCOs operated at 2 GHz are much better in phase noise than VCOs operated at 4 GHz to 5 GHz. The increase in phase noise due to said frequency doubling can be more than compensated by the use of the better performing 2-GHz VCOs.

[0060] In comparison with known solutions according to the present state of the art, the solution proposed by the underlying invention manages with a much lower power consumption. Further, it has an useful effect that all circuit elements used within the scope of said solution can be implemented with cheap components without thereby decreasing the quality of the data transfer. When being applied within the scope of portable mobile telecommunications devices, the claimed dual mode transceiver architecture according to the underlying invention can advantageously be integrated into conventional mobile stations due to its small number of components, its reduced board size and weight, its low power consumption, and its low cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0061] Further advantages and suitabilities of the underlying invention result from the subordinate claims as well as from the following description of two preferred embodiments of the invention which are depicted in the following drawings. In this case shows

FIG. 1 a functional block diagram 100 for a minimized ver-sion of the dual mode transceiver architecture for wireless communication in accordance with the first embodiment of the underlying invention, and

FIG. 2 a functional block diagram 200 for a specialized version of the dual mode transceiver architecture for wireless communication in accordance with the second embodiment of the underlying invention.

DETAILED DESCRIPTION OF THE UNDERLYING INVENTION

[0062] In the following the functions of the components comprised in a first embodiment of the underlying invention as depicted in block diagram 100 of figure 1 are explained.

[0063] The aforementioned block diagram 100 comprises a dual mode transceiver architecture for transmitting and receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges in accordance with patent claims 3 to 11, having a first transmission chain (TX_1) and a first reception chain (RX_1) for a first frequency range, and a second transmission chain (TX_2) and a second reception chain (RX_2) for a second frequency range. The claimed dual mode transceiver according to said first embodiment shows a symmetrical architecture as the structure of said receive chains is identical with that of said transmit chains.

[0064] When receiving a modulated RF signal from the antenna 101, a receive (RX) chain can be selected for either 2.450 GHz ISM operation (according to the IEEE 802.11b standard) or 5.150 GHz to 5.875 GHz operation by a TX/RX selection switch 102. When transmitting a modulated RF signal, a transmit (TX) chain can also be selected for either 2.450 GHz ISM operation (according to the IEEE 802.11b standard) or 5.150 GHz to 5.875 GHz operation by said TX/RX selection switch 102. Both said TX and said RX chain can also be applied separately within the scope of the corresponding transmitter and receiver devices, respectively.

[0065] The said receive chain comprises a switch 103 for switching between 2.450 GHz ISM or 5.150 GHz to 5.875 GHz operation, bandpass filtering means 109, 110 and 124 for band selection and/or image rejection, respectively, amplifying means 105, 106 and 122 for adjusting the signal amplitude of the received signal, at least one mixer 115 for a signal downconversion of a received signal frequency within said first or second reception range, respectively, and demodulation means 126 for demodulating a modulated signal which outputs the data signal to be received.

[0066] After a first amplification of the received (RX) 2.450 GHz signal with a first variable gain amplifier 105 (VGA) used as a low noise amplifier (LNA), a first RF bandpass filter 109 is employed in order to perform a band selection and/or an image rejection. When receiving a RF signal within the bandwidth of 5.150 GHz to 5.875 GHz, a first amplification of the received (RX) 5.150 GHz to 5.875 GHz signal with a first variable gain amplifier 106 (VGA) used as a low noise amplifier (LNA) is done, and a first RF bandpass filter 110 is employed in order to perform a band selection and/or an image rejection. A switch 113 coupled to the switch 117 serves to select the corresponding 2.450 GHz RX or 5.150 GHz to 5.875 GHz signal, respectively, for further signal processing. With the aid of the mixer 115 the received signal is downconverted to an intermediate frequency (IF) at 280 MHz. A second variable gain amplifier 122 (VGA) serves to readjust the signal amplitude of the downconverted signal. It is followed by a band-pass filter 124 (centered around 280 MHz) used for filtering the downconverted signal and removing unwanted mixing products. Finally, the received signal is led to a demodulator 126 which demodulates the downconverted RF signal to the baseband and outputs the data signal to be received.

[0067] In case of transmit operation, an analog baseband signal representing the data signal to be transmitted is modulated by means of a modulator 127 that outputs a modulated RF signal at said intermediate frequency (IF). A first variable gain amplifier 123 (VGA) serves to readjust the signal amplitude of the signal. It is followed by a bandpass filter 125 (centered around 280 MHz) used for filtering the signal and removing unwanted signal components. The filtered signal is then upconverted with the aid of a mixer 116. A switch 114 coupled to the switch 118 serves to select the corresponding 2.450 GHz TX or 5.150 GHz to 5.875 GHz TX chain for further signal processing. When operating in the 2.450 GHz TX mode a second variable gain amplifier 107 (VGA) is used to readjust the signal amplitude of the upconverted 2.450 GHz signal in order to provide an adequate output power followed by a bandpass filter 111 (centered around 2.450 GHz) used for filtering the upconverted 2.450 GHz signal and removing unwanted mixing products. When operating in the 5.150 GHz to 5.875 GHz TX mode a second variable gain amplifier 108 (VGA) is used to readjust the signal amplitude of the upconverted 5.150 GHz to 5.875 GHz signal in order to provide an adequate output power followed by a bandpass filter 112 (centered around 5,400 MHz) used for filtering the upconverted 5.150 GHz to 5.875 GHz signal and removing unwanted mixing products. Finally, the upconverted RF signal is led to the antenna 101 by

means of the switches 104 and 102 to be transmitted.

[0068] The object of the voltage controlled oscillator 119 (VCO1 is to provide a modulation frequency for said modulator 127 and said demodulator 126. The voltage controlled oscillators 120 (VCO2) and 121 (VCO3) act as local oscillators (LO) for the downconversion mixer 115 and the upconversion mixer 116, respectively. The output frequency of the voltage controlled oscillators 120 (VCO2) can be tuned within a range of 4,870 to 5,570 MHz; the output frequency of the voltage controlled oscillators 121 (VCO3) is 2,170 MHz. With the aid of the switch 117 coupled to switch 113 the downconversion mixer 115 can be provided with the correct mixing frequency. With the aid of the switch 118 coupled to switch 114 the upconversion mixer 116 can be provided with the correct mixing frequency.

[0069] In the following the functions of the components comprised in a second embodiment of the underlying invention as depicted in block diagram 200 of figure 2 are explained.

[0070] The aforementioned block diagram 200 comprises a dual mode transceiver architecture for transmitting and receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges in accordance with patent claims 14 to 26, having a first transmission chain (TX_1) and a first reception chain (RX_1) for a first frequency range, and a second transmission chain (TX_2) and a second reception chain (RX_2) for a second frequency range. Both said TX and said RX chains can also be applied separately within the scope of the corresponding transmitter and receiver devices, respectively.

2.450 GHz ISM (IEEE 802.11b) specific blocks

[0071] When receiving a signal from the two antennas 201a or 201b of the receive (RX) chain, the stronger signal component is selected with the first switch 203. After the first RF bandpass filter 205 used for the band selection and an image rejection, and a selection of the transmit or receive chain by a TX/RX selection switch 207 a first amplification with a first variable gain amplifier 209 (VGA) of the 2.450 GHz chain used as a low noise amplifier (LNA) is done followed by a second image rejection filter 211 and an amplification by an amplifier 213.

[0072] The transmit (TX) signal coming from the baseband unit is modulated with the aid of an I/Q modulator 235a and amplified by means of an amplifier 233 followed by a bandpass filter 220 to remove unwanted mixing products. After that the signal is amplified by means of a variable gain amplifier 231 (VGA) and upconverted by means of a mixer 236 followed by a bandpass filter 225 to remove unwanted mixing products. Then it is amplified to the allowed output power by an amplifier 227 preceded by a tunable attenuator 228b, switched to a second bandpass filter 205, and finally switched to the antenna diversity switch 203 of one of the two antennas 201a or 201b, respectively.

5.150 GHz to 5.875 GHz specific blocks

[0073] When receiving a signal from the two antennas 202a or 202b of the receive (RX) chain, the stronger signal component is selected with the first switch 204. After the first RF bandpass filter 206 used for the band selection and an image rejection, and a selection of th transmit or receive chain by a TX/RX selection switch 208 a first amplification with a first variable gain amplifier 210 (VGA) of the 5.150 GHz to 5.875 GHz chain used as a low noise amplifier (LNA) is done followed by a second bandpass filter 212 for further image rejection. A first downconversion to a high IF of approximately 120% of the covered frequency range (5.150 GHz to 5.875 GHz) is done by means of a mixer 221. After the mixing stage 221 first intermediate frequency (IF_1) filtering is done by means of a bandpass filter 223 followed by an amplifier stage 214 to compensate the filter losses.

[0074] The transmit (TX) signal coming from the baseband unit is modulated with the aid of an I/Q modulator 235a and amplified by means of an amplifier 233 followed by a bandpass filter 220 to remove unwanted mixing products. After that the signal is amplified by means of a variable gain amplifier 231 (VGA) and upconverted by a mixer 218 followed by a bandpass filter 224 to remove unwanted mixing products. Then it is amplified to the allowed output power by an amplifier 226. After being submitted to a second upconversion by means of the mixer 222, the signal is amplified to the allowed output power by an amplifier 238 preceded by a tunable attenuator 228a and a bandpass filter 237, switched to a second bandpass filter 206, and finally to the antenna diversity switch 204 of one of the two antennas 202a or 202b.

Shared blocks for receive (RX) operation

[0075] The signal from the two different chains for the 2.450 GHz band and the 5.150 GHz to 5.875 GHz band, respectively, is selected with a switch 215 followed by a second downconversion stage 217 and an intermediate frequency (IF) bandpass filter 219. At the output of this filter a final signal amplification by variable gain amplifier 229 and 230 (VGAs), an amplifier 232 and a demodulation of the signal by an I/Q demodulator 234a is done.

Shared blocks for transmit (TX) operation

[0076] The baseband signal is modulated with an I/Q modulator 235a followed by an amplification stage 233 and a bandpass filter 220 to remove unwanted mixing products amplified again to compensate the filter losses fed to the dedicated TX chains.
[0077] The following paragraphs refer to the generation of the local oscillator signals which are employed in said second embodiment of the present invention.

2.450 GHz ISM mode

[0078] The voltage controlled oscillator 243 (VCO3) acts as a local oscillator (LO) for the down-/upconversion mixer 217 and 236, and the voltage controlled oscillator 241 (VCO1) acts as a local oscillator (LO) for the I/Q modulator 235a or demodulator 234a, respectively.
[0079] Thereby, all parts of said transceiver architecture referring to the 5.150 GHz to 5.875 GHz RX/TX mode can be disabled. Likewise, the first intermediate frequency stage (1,200 MHz) used for the 5.150 GHz to 5.875 GHz operation can be disabled.

5.150 GHz to 5.875 GHz mode

[0080] The voltage controlled oscillator 243 (VCO3) followed by a frequency doubler 244 acts as a local oscillator (LO) for the first downconversion or upconversion to the high IF by means of the mixers 221 or 222, respectively, and a second voltage controlled oscillator 242 (VCO2) is used for the downconversion or upconversion to the shared IF frequency of the voltage controlled oscillator 242 (VCO2) by means of the mixers 217 or 218, respectively. The voltage controlled oscillator 241 (VCO1) does the same as described in the paragraph for 2.450 GHz ISM mode.
[0081] The meaning of the symbols designated with reference signs in figure 1 and figure 2 can be taken from the following table of reference signs.
[0082] Table of the depicted features and their corresponding reference signs

No.	Feature
100	block diagram of the claimed dual mode transceiver architecture for digital wireless communication in accordance with the first embodiment of the present invention
101	TX/RX-antenna for transmitting or receiving a RF signal belonging to the 2.450 GHz TX/RX chain or to the 5.150 GHz to 5.875 GHz TX/RX chain, respectively
102	switch for switching between transmit (TX) operation or receive (RX) operation, respectively
103	switch for switching to the 2.450 GHz RX chain or the 5.150 GHz to 5.875 GHz RX chain, respectively
104	switch for switching to the 2.450 GHz TX chain or the 5.150 GHz to 5.875 GHz TX chain, respectively
105	first variable gain amplifier (VGA) for receive operation belonging to the 2.450 GHz RX chain used as a low noise amplifier (LNA)
106	first variable gain amplifier (VGA) for receive operation belonging to the 5.150 GHz to 5.875 GHz RX chain used as a low noise amplifier (LNA)
107	second variable gain amplifier (VGA) belonging to the 5.150 GHz to 5.875 GHz TX chain
108	second variable gain amplifier (VGA) belonging to the 2.450 GHz TX chain
109	first RF bandpass filter (around 2,450 MHz) belonging to the 2.450 GHz RX chain used for band selection and/or image rejection
110	first RF bandpass filter (around 5,400 MHz) belonging to the 5.150 GHz to 5.875 GHz RX chain used for band selection and/or image rejection
111	second RF bandpass filter (around 5,400 MHz) for transmit operation belonging to the 5.150 GHz to 5.875 GHz TX chain
112	second RF bandpass filter (around 2,450 MHz) for transmit operation belonging to the 2.450 GHz TX chain
113	switch for switching the 2.450 GHz RX chain or the 5.150 GHz to 5.875 GHz RX chain to the downconversion mixer 115

(continued)

No.	Feature
114	switch for switching the upconverted signal coming from the upconversion mixer 116 to the 2.450 GHz TX chain or the 5.150 GHz to 5.875 GHz TX chain, respectively
115	downconversion mixer (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
116	upconversion mixer (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
117	switch, coupled with 113, for switching the signal of 120 (VCO2) or 121 (VCO3) to the downconversion mixer 115
118	switch, coupled with 114, for switching the signal of 120 (VCO2) or 121 (VCO3) to the upconversion mixer 116
119	first voltage controlled oscillator (VCO1) around 280 MHz
	for the modulation or demodulation, respectively (= shared component of the 2.450 GHz TX/RX chains and the 5.150 GHz to 5.875 GHz TX/RX chains)
120	second voltage controlled oscillator (VCO2) (range: 4,870 to 5,570 MHz) for downconversion or upconversion of the 5.150 GHz to 5.875 GHz TX/RX signal, respectively (= shared component of the 2.450 GHz TX/RX chains and the 5.150 GHz to 5.875 GHz TX/RX chains)
121	third voltage controlled oscillator (VCO3) around 2,170 MHz for downconversion or upconversion of the 2,450 MHz TX/RX signal, respectively (= shared component of the 2.450 GHz TX/RX chains and the 5.150 GHz to 5.875 GHZ TX/RX chains)
122	second variable gain amplifier (VGA) for receive operation (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
123	first variable gain amplifier (VGA) for transmit operation (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
124	intermediate frequency (IF) bandpass filter (around 280 MHz) used for filtering an intermediate frequency (IF) (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
125	intermediate frequency (IF) bandpass filter (around 280 MHz) used for filtering an intermediate frequency (IF) (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
126	demodulator (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
127	modulator (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
128	receive chains (RX_1, RX_2) of the claimed dual mode transceiver architecture for 2.450 GHz RX operation and 5.150 GHz to 5.875 GHz RX operation, respectively
129	transmit chains (TX_1, TX_2) of the claimed dual mode transceiver architecture for 2.450 GHz TX operation and 5.150 GHz to 5.875 GHz TX operation, respectively
200	block diagram of the claimed dual mode transceiver architecture for digital wireless communication in accordance with the second embodiment of the present invention
201a	TX/RX-antenna for transmitting or receiving a RF signal belonging to the 2.450 GHz TX/RX chain
201b	TX/RX-antenna for transmitting or receiving a RF signal belonging to the 2.450 GHz TX/RX chain
202a	TX/RX-antenna for transmitting or receiving a RF signal belonging to the 5.150 GHz to 5.875 GHz TX/RX chain
202b	TX/RX-antenna for transmitting or receiving a RF signal belonging to the 5.150 GHz to 5.875 GHz TX/RX chain
203	antenna diversity switch belonging to the 2.450 GHz TX/RX chain
204	antenna diversity switch belonging to the 5.150 GHz to 5.875 GHz TX/RX chain

(continued)

No.	Feature
205	first RF bandpass filter (around 2,450 MHz) belonging to the 2.450 GHz TX/RX chain used for band selection and image rejection
206	first RF bandpass filter (around 5,400 MHz) belonging to the 5.150 GHz to 5.875 GHz TX/RX chain used for band selection and image rejection
207	TX/RX selection switch belonging to the 2.450 GHz TX/RX chain
208	TX/RX selection switch belonging to the 5.150 GHz to 5.875 GHz TX/RX chain
209	first variable gain amplifier (VGA) belonging to the 2.450 GHz RX chain used as a low noise amplifier (LNA)
210	first variable gain amplifier (VGA) belonging to the 5.150 GHz to 5.875 GHz RX chain used as a low noise amplifier (LNA)
211	second bandpass filter (around 2,450 MHz) belonging to the 2.450 GHz RX chain used for image selection
212	second bandpàss filter (around 5,400 MHz) belonging to the 5.150 GHz to 5.875 GHz RX chain used for image selection
213	amplifier belonging to the 2.450 GHz RX chain
214	amplifier belonging to the 5.150 GHz to 5.875 GHz RX chain
215	switch for switching the 2.450 GHz RX chain or the 5.150 GHz to 5.875 GHz RX chain to the second downconversion mixer 217
216	switch, coupled with 215, for switching the signal of 242 (VCO2) or 243 (VCO3) to the second downconversion mixer 217
217	second downconversion mixer (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
218	first upconversion mixer belonging to the 5.150 GHz to 5.875 GHz TX chain
219	intermediate frequency (IF) bandpass filter (around 280 MHz) used for filtering the second (low) intermediate frequency (IF_2) (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
220	intermediate frequency (IF) bandpass filter (around 280 MHz) used for filtering the second (low) intermediate frequency (IF_2) (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
221	first downconversion mixer belonging to the 5.150 GHz to 5.875 GHz RX chain
222	second upconversion mixer belonging to the 5.150 GHz to 5.875 GHz TX chain
223	third RF bandpass filter (around 1,200 MHz) belonging to the 5.150 GHz to 5.875 GHz RX chain used for filtering the first (high) intermediate frequency (IF_1)
224	third RF bandpass filter (around 1,200 MHz) belonging to the 5.150 GHz to 5.875 GHz TX chain used for filtering the first (high) intermediate frequency (IF_1)
225	second RF bandpass filter (around 2,450 MHz) belonging to the 2.450 GHz TX chain
226	amplifier belonging to the 5.150 GHz to 5.875 GHz TX chain
227	amplifier belonging to the 2.450 GHz TX chain
228a	tunable attenuator belonging to the 5.150 GHz to 5.875 GHz TX chain
228b	tunable attenuator belonging to the 2.450 GHz TX chain
229	variable gain amplifier (VGA) (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
230	variable gain amplifier (VGA) (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)

(continued)

No.	Feature
231	variable gain amplifier (VGA) (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
232	amplifier (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
233	amplifier (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
234a	I/Q demodulator (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
234b	first mixer belonging to the I/Q demodulator (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
234c	second mixer belonging to the I/Q demodulator (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz RX chain)
235a	I/Q modulator (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
235b	first mixer belonging to the I/Q modulator (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
235c	second mixer belonging to the I/Q modulator (= shared component of the 2.450 GHz TX chain and the 5.150 GHz to 5.875 GHz TX chain)
236	first upconversion mixer belonging to the 2.450 GHz TX chain
237	second RF bandpass filter (around 5,400 MHz) belonging to the 5.150 GHz to 5.875 GHz TX chain
238	amplifier belonging to the 5.150 GHz to 5.875 GHz TX chain
239	connector symbol for the 2.450 GHz TX chain according to the IEEE 802.11b standard
240	connector symbol for the 2.450 GHz TX chain according to the IEEE 802.11b standard
241	first voltage controlled oscillator (VCO1) around 280 MHz for the I/Q-modulation or I/Q-demodulation, respectively (= shared component of the 2.450 GHz TX/RX chains and the 5.150 GHz to 5.875 GHz TX/RX chains)
242	second voltage controlled oscillator (VCO2) around 920 MHz for downconversion or upconversion, respectively, to the
	shared intermediate frequency (IF) (= shared component of the 2.450 GHz RX chain and the 5.150 GHz to 5.875 GHz TX/RX chains)
243	third voltage controlled oscillator (VCO3) (range: 1,920 to 2,250 MHz) for the first and second downconversion or upconversion, respectively (= shared component of the 2.450 GHz TX/RX chains and the 5.150 GHz to 5.875 GHz TX/RX chains)
244	frequency doubler (= shared component of the 5.150 GHz to 5.875 GHz TX chain and the 5.150 GHz to 5.875 GHz RX chain)
245	receive chains (RX_1, RX_2) of the claimed dual mode transceiver architecture for 2.450 GHz RX operation and 5.150 GHz to 5.875 GHz RX operation, respectively
246	transmit chains (TX_1, TX_2) of the claimed dual mode transceiver architecture for 2.450 GHz TX operation and 5.150 GHz to 5.875 GHz TX operation, respectively

[0083] In general, those skilled in the art will readily recognize that the realization of the underlying invention is not restricted to the above-described examples. Many modifications and variations may be made to the embodiments of the present invention disclosed herein without substantially departing from the scope of the invention as defined in the following claims.

Claims

1. A dual mode receiver for receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges, having a first reception chain (RX_1) for a first frequency range, and a second reception chain (RX_2) for a second frequency range,
wherein said dual mode receiver comprises:

- at least one antenna for receiving radio frequency (RF) signals,
- frequency synthesizing means for providing at least two different reference frequencies,
- switching means for switching between said first and said second reception chain, respectively,
- at least one mixer for a signal downconversion of a received signal frequency within said first or second reception range, respectively,

characterized in that
at least one of said mixers can be selectively connected to at least two of said frequency synthesizing means, wherein said signal downconversion mixer of a received signal frequency within said first reception range is also used as said signal downconversion mixer of a received signal frequency within said second reception range.

2. A dual mode transmitter for transmitting modulated radio frequency (RF) signals operating on at least two different frequency ranges, having a first transmission chain (TX_1) for a first frequency range, and a second transmission chain (TX_2) for a second frequency range,
wherein said dual mode transmitter comprises:

- at least one antenna for transmitting radio frequency (RF) signals,
- frequency synthesizing means for providing at least two different reference frequencies,
- switching means for switching between said first and said second transmission chain, respectively,
- at least one mixer for a signal upconversion of a transmitted signal frequency within said first or second transmission range, respectively,

characterized in that
at least one of said mixers can be selectively connected to at least two of said frequency synthesizing means, wherein said signal upconversion mixer of a transmitted signal frequency within said first transmission range is also used as said signal upconversion mixer of a transmitted signal frequency within said second transmission range.

3. A dual mode transceiver for transmitting and receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges,
having a first transmission chain (TX_1) and a first reception chain (RX_1) for a first frequency range, and
having a second transmission chain (TX_2) and a second reception chain (RX_2) for a second frequency range,
wherein said dual mode transceiver comprises:

- at least one antenna (101) for transmitting and receiving radio frequency (RF) signals, respectively,
- frequency synthesizing means (120, 121) for providing at least two different reference frequencies,
- switching means (102-104, 113, 114, 117, 118) for switching between transmit or receive operation, respectively, and for switching between said first and said second transmission chain and reception chain, respectively,
- at least one mixer (115) for a signal downconversion of a received signal frequency within said first or second reception range, respectively,
- at least one mixer (116) for a signal upconversion of a transmitted signal frequency within said first or second transmission range, respectively,

characterized in that
at least one of said mixers (115, 116) can be selectively connected to at least two of said frequency synthesizing means (120, 121), wherein
said signal downconversion mixer (115) of a received signal frequency within said first reception range is also used as said signal downconversion mixer of a received signal frequency within said second reception range, and
said signal upconversion mixer (116) of a transmitted signal frequency within said first transmission range is also used as said signal upconversion mixer of a transmitted signal frequency within said second transmission range.

4. A dual mode transceiver according to claim 3,
comprising:

- modulation means (127) for modulating a RF carrier signal and providing a modulated RF signal in accordance with the data signal to be transmitted, and
- demodulation means (126) for demodulating a modulated RF signal in order to rebuild said data signal,
- frequency synthesizing means (119) for providing a reference frequency,

wherein said frequency synthesizer (119) is a voltage controlled oscillator (VCO1) that provides a reference frequency for said modulation means (127) and said demodulation means (126).

5. A dual mode transceiver according to anyone of the claims 3 or 4,
wherein said frequency synthesizer (120) is a voltage controlled oscillator (VCO2) that provides a reference frequency for said mixer (115) for the signal downconversion of a received signal frequency and said mixer (116) for the signal upconversion of a transmitted signal frequency.

6. A dual mode transceiver according to anyone of the claims 3 to 5,
wherein said frequency synthesizer (121) is a voltage controlled oscillator (VCO3) that provides a reference frequency for said mixer (115) for the signal downconversion of a received signal frequency and said mixer (116) for the signal upconversion of a transmitted signal frequency.

7. A dual mode transceiver according to anyone of the claims 3 to 6,
wherein an intermediate frequency (IF) and filtering means (124, 125) for said intermediate frequency (IF) are used to remove adjacent channel interferers.

8. A dual mode transceiver according to anyone of the claims 4 to 7,
wherein said modulation means (127) is an I/Q modulator and said demodulation means (126) is an I/Q demodulator.

9. A dual mode transceiver according to anyone of the claims 3 to 8,
wherein said first frequency range for a first transmission (TX_1) and/or a first reception (RX_1) of signals has a center frequency of 2.450 GHz.

10. A dual mode transceiver according to anyone of the claims 3 to 9,
wherein said second frequency range for a second transmission (TX_2) and/or a second reception (RX_2) of signals is the range between 5.150 GHz and 5.875 GHz.

11. A dual mode transceiver according to the claims 7 to 10,
wherein said intermediate frequency (IF) has a value of 280 MHz.

12. A dual mode receiver for receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges, having a first reception chain (RX_1) for a first frequency range, and a second reception chain (RX_2) for at least one second frequency range,
wherein said dual mode receiver comprises:

- at least one antenna (201a, 201b) for receiving radio frequency (RF) signals,
- frequency synthesizing means (242, 243) for providing at least two different reference frequencies,
- switching means (215) for switching between said first and said second reception chain, respectively,
- at least one mixer (221) for a first signal downconversion of a received signal frequency within said first reception range,
- at least one mixer (217) for the second signal downconversion of a received signal frequency within said first reception range,
- at least one mixer (217) for the second signal downconversion of a received signal frequency within said second reception range,

characterized in that
the frequency tuning range of at least one of said frequency synthesizer means (243) can be reduced by means of a circuit comprising a frequency multiplier (244), and that at least one of the mixers (217) can be selectively

connected to at least two of said frequency synthesizing means (242, 243).

13. A dual mode transmitter for transmitting modulated radio frequency (RF) signals operating on at least two different frequency ranges, having a first transmission chain (TX_1) for a first frequency range, and a second transmission chain (TX_2) for at least one second frequency range,
wherein said dual mode transmitter comprises:

- at least one antenna (202a, 202b) for transmitting radio frequency (RF) signals,
- frequency synthesizing means (242, 243) for providing at least two different reference frequencies,
- at least one mixer (218) for the first signal upconversion of a transmitted signal frequency within said first reception range,
- at least one mixer (222) for a second signal upconversion of a transmitted signal frequency within said first reception range,
- at least one mixer (236) for the first signal upconversion of a transmitted signal frequency within said second reception range,

characterized in that
the frequency tuning range of at least one of said frequency synthesizer means (243) can be reduced by means of a circuit comprising a frequency multiplier (244), and that at least one of the mixers (218, 222) can be selectively connected to at least two of said frequency synthesizing means (242, 243).

14. A dual mode transceiver for transmitting and receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges,
having a first transmission chain (TX_1) and a first reception chain (RX_1) for a first frequency range, and having a second transmission chain (TX_2) and a second reception chain (RX_2) for at least one second frequency range,
wherein said dual mode transceiver comprises:

- at least one antenna (201a, 201b, 202a, 202b) for transmitting and receiving radio frequency (RF) signals, respectively,
- frequency synthesizing means (242, 243) for providing at least two different reference frequencies,
- switching means (207, 208, 215) for switching between transmit or receive operation, respectively, and for switching between said first and said second transmission chain and reception chain, respectively,
- at least one mixer (221) for a first signal downconversion of a received signal frequency within said first reception range,
- at least one mixer (217) for the second signal downconversion of a received signal frequency within said first reception range,
- at least one mixer (217) for the second signal downconversion of a received signal frequency within said second reception range,
- at least one mixer (218) for the first signal upconversion of a transmitted signal frequency within said first reception range,
- at least one mixer (222) for a second signal upconversion of a transmitted signal frequency within said first reception range,
- at least one mixer (236) for the first signal upconversion of a transmitted signal frequency within said second reception range,

characterized in that
the frequency tuning range of at least one of said frequency synthesizer means (243) can be reduced by means of a circuit comprising a frequency multiplier (244), and that at least one of the mixers (217) can be selectively connected to at least two of said frequency synthesizing means (242, 243).

15. A dual mode transceiver according to claim 14,
wherein said second signal downconversion mixer (217) of a received signal frequency within said first reception range is also used as said second signal downconversion mixer (217) of a received signal frequency within said second reception range.

16. A dual mode transceiver according to anyone of the claims 14 or 15, comprising:

- modulation means (235a) for modulating a RF carrier signal and providing a modulated RF signal in accord-

ance with the data signal to be transmitted, and
- demodulation means (234a) for demodulating a modulated RF signal in order to rebuild said data signal,
- frequency synthesizing means (241) for providing a reference frequency,

wherein said frequency synthesizer (241) is a voltage controlled oscillator (VCO1) that provides a reference frequency for said modulation means (235a) and said demodulation means (234a).

17. A dual mode transceiver according to anyone of the claims 14 to 16, wherein said frequency synthesizer (242) is a voltage controlled oscillator (VCO2) that provides a reference frequency for said mixer (217) for the second signal downconversion of a received signal frequency and said mixer (218) for the first signal upconversion of a transmitted signal frequency.

18. A dual mode transceiver according to anyone of the claims 14 to 17, wherein said frequency synthesizer (243) is a voltage controlled oscillator (VCO3) that provides a reference frequency for said mixer (217) for the second signal downconversion of a received signal frequency, said mixer (236) for the first signal upconversion of a transmitted signal frequency, and said frequency doubler (244).

19. A dual mode transceiver according to anyone of the claims 14 to 18, wherein said mixer (221) for the first signal downconversion of a received signal frequency and said mixer (222) for the second signal upconversion of a transmitted signal frequency are both supplied with the doubled reference frequency of said frequency synthesizer (243), wherein said reference frequency is multiplied with a factor of two by said frequency multiplier (244).

20. A dual mode transceiver according to anyone of the claims 14 to 19, wherein a first intermediate frequency (IF_1) and filtering means (223, 224) for this first intermediate frequency (IF_1) are used to provide an image rejection.

21. A dual mode transceiver according to claim 20, wherein a second intermediate frequency (IF_2), which is lower than IF_1, and filtering means (219, 220) for this second intermediate frequency (IF_2) are used to remove adjacent channel interferers.

22. A dual mode transceiver according to anyone of the claims 16 to 21, wherein said modulation means (235a) is an I/Q modulator and said demodulation means (234a) is an I/Q demodulator.

23. A dual mode transceiver according to anyone of the claims 14 to 22, wherein said first frequency range for a first transmission (TX_1) and/or a first reception (RX_1) of signals has a center frequency of 2.450 GHz.

24. A dual mode transceiver according to anyone of the claims 14 to 23, wherein said second frequency range for a second transmission (TX_2) and/or a second reception (RX_2) of signals is the range between 5.150 GHz and 5.875 GHz.

25. A dual mode transceiver according to the claims 20 to 24, wherein said first intermediate frequency (IF_1) has a value of 1,200 MHz.

26. A dual mode transceiver according to the claims 21 to 25, wherein said second intermediate frequency (IF_2) has a value of 280 MHz.

27. A method for receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges, using:

- at least one antenna (101) for receiving radio frequency (RF) signals,
- frequency synthesizing means (120, 121) for providing at least two different reference frequencies,
- switching means (103, 113, 117) for switching between said first and said second reception chain, respectively,
- at least one mixer (115) for a signal downconversion of a received signal frequency within said first or second reception range, respectively,

characterized in that
said signal downconversion mixer (115) can be selectively connected to at least two of said frequency synthesizing means (120, 121), wherein said signal downconversion mixer (115) of a received signal frequency within said first reception range is also used as said signal downconversion mixer of a received signal frequency within said second reception range.

28. A method for receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges according to claim 27, comprising

- means (115) for a downconversion of a received radio frequency (RF) signal to at least one intermediate frequency (IF), and
- filtering means (109, 110, 124) for said intermediate frequency (IF) and said radio frequency (RF), respectively, to remove adjacent channel interferers and/or to perform an image rejection.

29. A method for transmitting modulated radio frequency (RF) signals operating on at least two different frequency ranges, using:

- at least one antenna (101) for transmitting radio frequency (RF) signals,
- frequency synthesizing means (120, 121) for providing at least two different reference frequencies,
- switching means (104, 114, 118) for switching between said first and said second transmission chain, respectively,
- at least one mixer (116) for a signal upconversion of a transmitted signal frequency within said first or second transmission range, respectively,

characterized in that
said signal upconversion mixer (116) can be selectively connected to at least two of said frequency synthesizing means (120, 121), wherein
said signal upconversion mixer (116) of a transmitted signal frequency within said first transmission range is also used as said signal upconversion mixer of a transmitted signal frequency within said second transmission range.

30. A method for transmitting modulated radio frequency (RF) signals operating on at least two different frequency ranges according to claim 29, comprising

- means (116) for an upconversion of a signal at said intermediate frequency (IF) to said radio frequency (RF), and
- filtering means (111, 112, 125) for said intermediate frequency (IF) and said radio frequency (RF), respectively.

31. A method for transmitting and/or receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges, using:

- at least one antenna (101) for transmitting and receiving radio frequency (RF) signals, respectively,
- frequency synthesizing means (120, 121) for providing at least two different reference frequencies,
- switching means (102-104, 113, 114, 117, 118) for switching between transmit or receive operation, respectively, and for switching between said first and said second transmission chain and reception chain, respectively,
- at least one mixer (115) for a signal downconversion of a received signal frequency within said first or second reception range, respectively,
- at least one mixer (116) for a signal upconversion of a transmitted signal frequency within said first or second transmission range, respectively,

characterized in that
at least one of said mixers (115, 116) can be selectively connected to at least two of said frequency synthesizing means (120, 121), wherein
said signal downconversion mixer (115) of a received signal frequency within said first reception range is also used as said signal downconversion mixer of a received signal frequency within said second reception range, and
said signal upconversion mixer (116) of a transmitted signal frequency within said first transmission range is also used as said signal upconversion mixer of a transmitted signal frequency within said second transmission range.

32. A method for transmitting and/or receiving modulated radio frequency (RF) signals operating on at least two different frequency ranges according to claim 31, comprising

- means (115) for a downconversion of a received radio frequency (RF) signal to at least one intermediate frequency (IF), and
- filtering means (109, 110, 124) for said intermediate frequency (IF) and said radio frequency (RF), respectively, to remove adjacent channel interferers and/or to perform an image rejection.
- means (116) for an upconversion of a signal at said intermediate frequency (IF) to said radio frequency (RF), and
- filtering means (111, 112, 125) for said intermediate frequency (IF) and said radio frequency (RF), respectively.

33. A mobile telecommunications device,
characterized in that
it comprises a dual mode receiver according to claim 1.

34. A mobile telecommunications device,
characterized in that
it comprises a dual mode transmitter according to claim 2.

35. A mobile telecommunications device,
characterized in that
it comprises a dual mode transceiver according to anyone of the claims 3 to 11.

36. A mobile telecommunications device,
characterized in that
it comprises a dual mode receiver according to claim 12.

37. A mobile telecommunications device,
characterized in that
it comprises a dual mode transmitter according to claim 13.

38. A mobile telecommunications device,
characterized in that
it comprises a dual mode transceiver according to anyone of the claims 14 to 26.

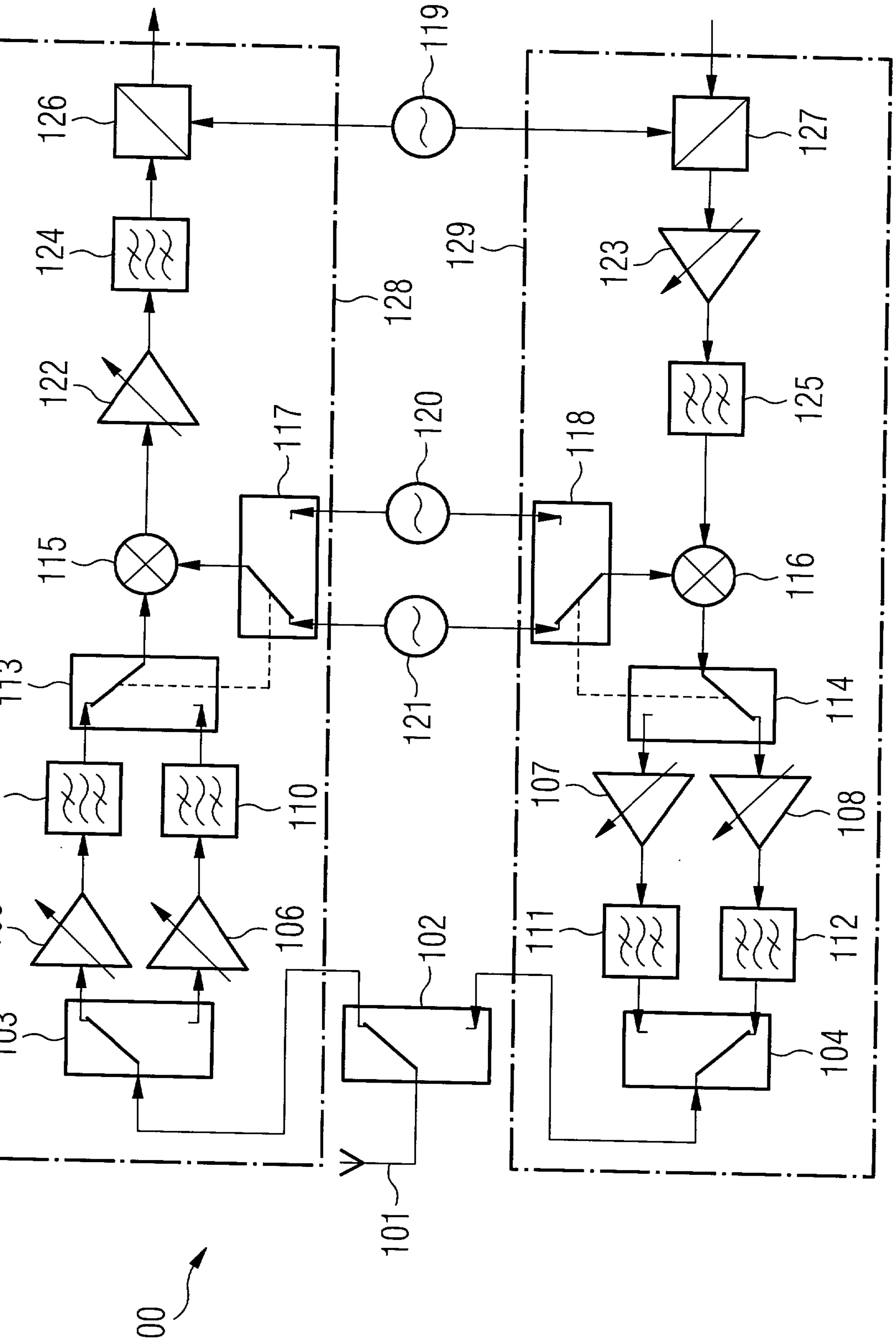
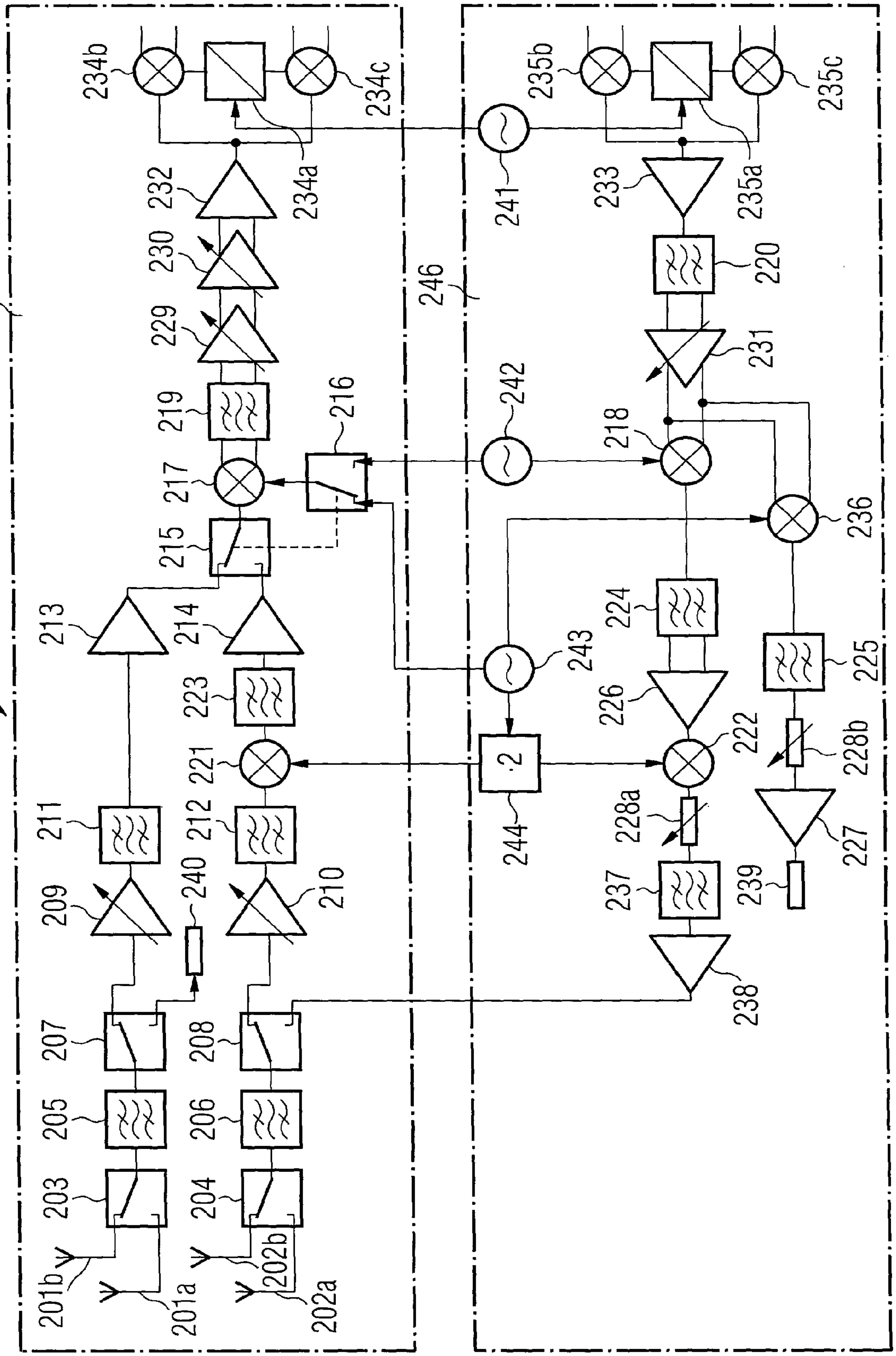

100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129

FIG 1

FIG 2


200
245
246
201a
201b
202a
202b
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228a
228b
229
230
231
232
233
234a
234b
234c
235a
235b
235c
236
237
238
239
240
241
242
243
244
:2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 11 2404

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X A	EP 0 744 831 A (MATSUSHITA ELECTRIC IND CO LTD) 27 November 1996 (1996-11-27) * abstract * * page 10, line 33 - page 12, line 12 * * page 17, line 43 - page 18, line 41 * * figure 2 *	1-11, 27-35 12-26, 36-38	H04B1/40
A	EP 0 793 356 A (NOKIA MOBILE PHONES LTD) 3 September 1997 (1997-09-03) * abstract * * column 3, line 58 - column 4, line 45 * * figure 2 *	1-38	
A	EP 0 945 990 A (BOSCH GMBH ROBERT) 29 September 1999 (1999-09-29) * abstract * * figure 3 * * column 4, line 24 - column 5, line 9 *	1-38	
A	US 4 322 856 A (OHTA SHIGEO ET AL) 30 March 1982 (1982-03-30) * abstract * * column 1, line 65 - column 2, line 23 * * figure 1 *	1-38	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 October 2001	Tzimeas, K

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 11 2404

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-10-2001

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 0744831	A	27-11-1996	JP	8316873	A	29-11-1996
			JP	8321738	A	03-12-1996
			JP	8330845	A	13-12-1996
			JP	9008627	A	10-01-1997
			DE	69615914	D	22-11-2001
			DE	69615914	T	04-04-2002
			EP	1146638	A	17-10-2001
			US	5926466	A	20-07-1999
EP 0793356	A	03-09-1997	FI	960947	A	30-08-1997
			US	5852603	A	22-12-1998
EP 0945990	A	29-09-1999	NONE			
US 4322856	A	30-03-1982	JP	55121740	A	19-09-1980

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82